IS/WP2-0224
29 JUL 92

Government of Canada
Department of Communications

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5270-6

13 July 1992

Mr. Berney D. Dayton
Chairman, SS/WP1 (Systems Analysis)
FCC Advisory Committee on Advanced Television Service
c/o NVISION, Inc.
P.O.Box 1658
Nevada City, Ca 95959

Dear Mr. Dayton;

At the last meeting of the Systems Subcommittee Working Party 1, the subject of the use of coverage extenders as suggested in the MIT/GI proposal to improve coverage of ATV broadcasting was discussed. Dr. R. Keeler's Task Force was then asked to define some additional systems specific tests to establish the capability of the proposed ATV systems to operate with these on-channel repeaters. I was unfortunately unable to participate in the discussions of the Task Force on this question although I had provided my comments before the meeting to Bob Keeler. The intent of this letter is to formally present you with findings that resulted from investigations conducted at CRC on this subject. You will find, attached herewith, a report on the results of these investigations.

In summary, the highlights of this report are that in order to allow for the presence of on-channel repeaters, the adaptive channel equalizer will need to meet tighter specifications in terms of: a) a wider equalization time window, and b) being able to equalize echoes that are as high as the main signal. The first additional constraint can be covered by the use of longer transversal filters and translates into more complex but relatively straightforward equalizer implementation. The second constraint is much more demanding and relates to the complexity of the convergence algorithm. In this case, it is not even proven that equalization of such high echoes is even possible.

There is therefore some fundamental work needed before the claim can be made that on-channel repeaters can be used in ATV broadcasting with the currently proposed modulation schemes. Consequently, it is extremely important that the ATTC measurement program should include echo tests that can exercise and verify the performance of the proposed ATV channel equalizers over the extended template given in Figure 2 of the attached report.

Canada

Through the field tests of Digital Audio Broadcasting (DAB) in Canada during the two last years (it was also demonstrated in Las Vegas during the 1990 NAB Convention), we were able to prove the feasibility and the advantage of the use of on-channel repeaters when a multi-carrier modulation is used. In this case, there is no such constraint as maximum level of echoes that can be corrected since, as long as these echoes are within a given time interval, they are power added constructively. We are planning to do more work in this field in Canada and especially at CRC. We will be pleased to keep you informed of any promising developments.

Meanwhile, I hope that these findings will prove to be useful in the assessment of the feasibility of this concept of on-channel coverage extenders by the Advisory Committee and especially in the work of your Working Party.

Yours sincerely,

Gérald Chouinard

encl.: 1

cc.:

R. Keeler (AT&T)
J. Cohen
K. Davies (CBC)
W. Sawchuk (CRC)

Study on the possibility of using on-channel coverage extenders in ATV broadcasting

Communications Research Centre

Gérald Chouinard

92.07.07

1. Introduction

Throughout the process of the FCC-ACATS in the U.S. and the work done in Canada by the JTCAB on ATV terrestrial broadcasting, there has always been a need recognized for the reduction of the power required to cover a given service area with ATV and the possibility of allocating all broadcasters especially in populated areas. Lately, MIT/GI suggested, in their ATV system proposal, the use of on-channel repeaters to extend the coverage of a central transmitter and possibly tailoring the coverage by selecting sites where these repeaters would be located. This concept is new in the ATV forum and needs to be fleshed out before clear positions can be taken on it. This idea is, however, not new in the context of digital sound broadcasting where modulations especially suited to accommodate these repeaters are being proposed.

The intent of this report is to build on the knowledge acquired in digital sound broadcasting and apply it to ATV in order to clarify the additional technical requirements resulting from the utilization of these on-channel repeaters.

It is recognized that an extensive study will need to be done in terms of coverage policy and service planning aspects due to the possibility of tailoring the coverage areas. The usual very high power levels required to cover as much as possible of a normally circular area would no longer be needed and the broadcasters may be, and perhaps may have to be, more selective in finding the best trade-off between extent of coverage and station revenues by choosing to cover only some specified areas such as the most populated areas. The philosophy in determining a station coverage could be radically different and would need to be investigated in terms of its policy implications. One aspect is the fact that a percentage of the population currently covered by NTSC would not necessarily be covered by ATV if the coverage is tailored to, say, the demographics. This report does not intend to address this aspect but it should be realized that this subject is as important and probably as complex to assess as the technical feasibility and it needs to be addressed early in the process.

2. Background

The concept of on-channel coverage extenders and gap-fillers was introduced in 1986 in the field of sound broadcasting in order to improve the service availability of the newly proposed digital sound broadcasting systems (see CCIR Report 955). In particular, the modulation proposed by the European Industry through the Eureka-147 project is specifically suited to accommodate the situation where a number of high level echoes produced by local on-channel repeaters would be present at the receiver.

The proposed multi-carrier modulation (Code Orthogonal Frequency Division Modulation: COFDM) stretches the symbol period, thus allowing for the insertion of a guard interval which is used as a time buffer to reduce inter-symbol interference caused by the passive echoes as well as the "active" echoes produced by the on-channel repeaters. This allows the receiver to perform on the basis of the total power of these echoes as long as they occur within this guard interval.

In the case of ATV, a similar multi-carrier modulation technique could be used to allow for the use of on-channel coverage extenders. However, since the data throughput required for ATV is much higher than in the case of a digital sound broadcasting service, this becomes a technical challenge since this type of modulation requires a real-time FFT with a throughput of about 20 Mbit/s in each receiver.

The alternative is to rely on an adaptive channel equalizer in each ATV receiver to remove these active echoes. Since all ATV system proponents use a channel equalizer to reduce the passive echoes and linear channel distortion, this would seem, a-priori, the easiest solution. The operation in an active echo environment will however imply a number of more demanding characteristics for the equalizer as will be seen in the following sections.

3. Additional performance requirements for the adaptive channel equalizer to accommodate on-channel repeaters

3.1 Extent of the time window to be covered by equalizer

It has been taken for granted that, considering typical passive echoes, the amplitude of these echoes would be at a certain level below the main signal and that this level would decrease with an increase in delay from the main signal until it becomes negligible beyond, say, 25 µsec (this depends much on the type of terrain and presence of buildings in the area). This has been the basis for the design of the channel equalizers currently included in the ATV system proposals. The claimed performances for these equalizers reflect these initial assumptions with correction for a certain level of echo out to a given delay beyond which only lower power echoes can be corrected (eg. -6 dB for -2 to +4 µsec, and -12 dB between +4 and +24 µsec; MIT/GI system), as shown in Figure 1.

In the case of active echoes produced by on-channel repeaters, depending on where the receiver is located within the coverage area, these active echoes can appear either before or after the main signal. In fact, at a specific location, two active echoes can be received at exactly the same power and depending whether the receiver is moved towards one repeater or the other (one can be the main transmitter), one echo will be higher than the other. Since all these echoes will be affected equally by passive echoes, the passive echo template described above should surround this new time symmetrical template. As an example, Figure 2 shows a template that would cover for active echoes over a time period of 32 µsec (ie. -16 to +16 µsec) beyond which the template for the passive echoes would apply.

3.2 Maximum amplitude of echoes to be equalized

As explained above, depending on the location of the receiver, an active echo can be as high as the signal from the main transmitter and even higher if the receiver is located even closer to the repeater. In such case, the receiver would need to synchronize on the higher power signal and the main signal would be perceived as a pre-echo. The limit case is when the two signals are received at the same amplitude. The template given in Figure 2 covers this limit case by specifying that the equalizer has to correct for echoes that are as powerful as the reference signal over the given time window. This situation is likely to occur in the cases where very simple receiving antennas such as rabbit ears are used where no azimuthal discrimination is available. In the case where a directional antenna is used, the user would tend to peak the antenna on the most powerful received signal and reduce the other echoes, therefore creating a less demanding situation for the equalizer.

It should also be noted that in order to secure a certain stability in the receiver for the synchronization of the receiver on the highest echo in the case of two or more echoes having almost the same power, some amount of hysteresis would be required to minimize continuous hunting in this specific situation. The echo equalizer should in fact be able to cancel an echo at slightly higher power than the main signal if it occurs in the given time period. An hysteresis range of 1 to 2 dB may be sufficient for practical static reception cases. Outside this active echo period, the same levels as assumed for passive echo cancellation should be assumed.

3.3 Performance of the echo equalizer

The other element is the extent at which the equalizer can remove echoes. Echo cancellation is equivalent, for digital transmission systems, to *minimizing* inter-symbol interference and is often expressed as maximizing the "eye height". This process results typically in an apparent reduction of the Carrier-to-Noise ratio (C/N). One could see the process in the frequency domain as the equalizer trying to boost the faded regions of the spectrum to bring the channel response as close as possible to flatness. In doing so, the noise in these spectral regions is also amplified, thus reducing the apparent C/N. This can be seen as an improvement in the Inter-Symbol Interference (ISI) at the expense of an apparent increase in channel noise. The extent of the reduction in C/N depends on the performance of the convergence algorithm used. The performance of the channel equalizer in terms of apparent increase in C/N is therefore critical and needs to be quantified before any conclusion on the feasibility of extending coverage with on-channel repeaters based on channel equalizers can be drawn.

The extent of the reduction in C/N also depends on the relative power of the echoes to be cancelled (larger the echo is, deeper the frequency selective fades are likely to be). A simple way to visualize this is to consider that a certain percentage of the echo power is translated into noise power, resulting in a reduction in C/N that is dependent on the power of the echo to be cancelled.

The modulation itself has much less to do with active and passive echoes than the channel equalizer. Some modulation and channel coding could give better performance in the case of ISI but the difference is small compared to the improvement obtained by the channel equalizer. All this to say that the question of channel equalization can be considered independently of the ATV system proposed in the case of all digital systems using quadrature amplitude modulation. In other words, the question debated here is a generic question which applies equally to all digital ATV systems and primarily relates to the performance of the channel equalizer and not to the specific digital modulation used.

4. Performance of the multi-carrier modulation

For the multi-carrier modulation, the extent of the time window over which active echoes from on-channel repeaters are likely to appear corresponds to the length of the guard interval required in the system. In order to keep the power requirement to a minimum, this guard interval needs to occupy only a fraction of the symbol period (say 20% which corresponds to 1 dB additional power requirement). Thus stretching the guard interval ends up in a longer symbol period. In order to keep the same throughput, the number of carriers then needs to be increased in the same proportion. This has two effects: a) the complexity of the real-time FFT used for the multi-carrier demodulation increases as a function of $\log^2 N$ where N is the number of carriers, and b) the tolerance on the phase noise of the RF front end must be tighter.

As far as the amplitude of the echoes is concerned, however, there is no constraint since this type of modulation relies on the power sum of all these echoes. This flexibility is a clear advantage for the multi-carrier modulation when coverage extenders are used.

Another advantage of the multi-carrier modulation scheme over the adaptive channel equalizer is that the equalization performed by the former is almost instantaneous whereas the latter requires a certain time to converge and eliminate echoes. This advantage will be clear in the case of airplane flutter and also in the case of the correction of the echo phase variation produced by a time jitter of the echo on a typical propagation path. As an example, for a UHF channel, a variation of only 9 to 16 cm in the path length of the echo would make the echo to move completely between the I and Q axes at a QAM demodulator.

5. Effect of the use of a channel equalizer or multi-carrier modulation on coverage achieved with on-channel repeaters

For the purpose of the exercise, we assumed a service area based on the most populated zone in the metropolitan Toronto. This is indicated by the shaded area in Figure 3. The shaded lines represent the shores of lake Ontario. The intent of the exercise was to compare the various ways this service area could be covered depending on the way the active echoes are handled in the receiver. Passive echoes were not considered in this exercise.

We used a software program that has been developed at CRC to synthesize the coverage of digital sound broadcasting using multi-carrier modulation with guard interval with and without on-channel repeaters. For this exercise, the system parameters were modified to reflect the parameters of the MIT/GI ATV system. These parameters can be found on page 9. The equivalent of the F(50,90) curves was used (ie. CCIR Rec.370). In the case of the channel equalizer, the active echo correction range was set at 32 μsec by artificially setting the symbol period at 32 μsec and assuming that the guard interval occupied 100% of the symbol period. Figure 3 gives the coverage achieved by a single transmitter located at an EHAAT of 300 m (on the CN Tower). The coverage is indicated by the iso-margin curves at 0 dB, +10 dB, +20 dB, +30 dB and +40 dB. Note that the darker contour is always the 0 dB margin contour outside which the service availability criterion is not met. The power required to cover the farthest point located at 50 km is 1,750 Watts which is consistent with the numbers proposed by MIT/GI for this radius of coverage.

In Figure 4, the coverage has been closely tailored to the service area by using 10 on-channel repeaters. The multi-carrier modulation (COFDM) has been assumed in this case with a 160 μsec total symbol period (1024 carriers) and 32 μsec guard interval which is equivalent to the channel equalizer correction window. In this case, all echoes falling inside the guard interval are power added and those falling outside this interval are seen as noise. There is however a transition period from fully constructive echoes to echoes fully contributing to the noise power that takes place over a symbol period on either side of the guard interval. No negative delay was allowed at the repeaters so that the signal could be picked-up off-air and re-transmitted. Negative delays which would imply more complex signal distribution to the repeaters through cable or micro-wave links would however give more freedom in the optimization of the coverage and would likely reduce the number of required repeaters for the same coverage. As can be seen, from page 11, the reduction in transmission power is dramatic, from 1,750 Watts, the main transmitter power requirement has now dropped to a mere 65 Watts with repeaters needing 5 to 20 Watts. Note that the antennas used are directive to reduce the amount of destructive echo towards the main transmitter.

Figure 5 gives the same tailored coverage in the case of the use of a perfect channel equalizer working over the same 32 μsec window. In this case, only the largest echo is used and all the other echoes are assumed to be perfectly cancelled inside the 32 μsec window and considered as noise outside this window. As can be seen from page 13, the power required at the repeaters is doubled compared to the multi-carrier modulation case. This is because rather than power adding echoes as in the case of the multi-carrier modulation, the equalizer relies on only one echo and cancels all the others.

However, perfect equalizers do not exist and even a slight increase of the apparent noise power due to echo cancellation inside the equalization window will have a major effect on the extent of coverage.

Figure 6 uses the same transmitter and repeater parameters as in the case of the perfect equalizer (Figure 5) but in this case, 5% of the active echo power is assumed to be contributing to the apparent noise increase at the receiver. As can be seen, a number of holes starts to appear in the coverage and the repeaters are becoming less effective. More of them would actually be needed to re-shape the coverage properly. The situation worsens very quickly as can be seen on Figure 7 where 10% of the echo power is transformed into noise and Figure 8 where 25% of the power is then seen as noise.

6. Interference aspects

It is clear that by shaping the contour of a service area with low power repeaters, the distance for frequency re-use can be drastically reduced. In fact, such shaping could be used to resolve severe problems of co-channel interference in very specific cases. More work needs to be done on this. The software program developed at CRC and used in the above exercises allows such co-channel interference study to be conducted. Some encouraging results have already been produced for digital sound broadcasting at 1.5 GHz which clearly proves this point.

In the case of interference into the adjacent channel, the use of repeaters may create some holes in the coverage of an adjacent channel transmitter covering the same service area since, close to the repeater, the receivers would be saturated by the main channel and unable to receive the adjacent channel, therefore creating a small dead spot for the adjacent channel unless the repeater carries both channels which would allow to preserve the power differential between the two channels. The extent of this problem is still to be investigated (ie. radius of the holes and the likelihood of having two adjacent channels assigned to the same service area.

7. Conclusion

It has been shown that on-channel repeaters can be used to tailor the coverage to a specific service area contour and dramatically reduce the required power of the main transmitter (eg. 1,750 Watts to 65 Watts). The use of on-channel repeaters is readily feasible when multi-carrier modulation is used with a guard interval since the receiver can rely on the power sum of the echoes contained in the guard interval. Almost as good coverage performance can be achieved with high quality adaptive channel equalizers if they can meet some specific requirements on top of the basic requirements for correcting passive echoes. These additional requirements are: a) extended range for the correction window, b) correction of echoes as powerful as the main signal, and c) minimal apparent increase of the channel noise caused by the equalization. If this new concept of coverage is to be pursued, the performance of the channel equalizers proposed with the various ATV systems need to be tested according to these new additional requirements.

atv-cov.ext

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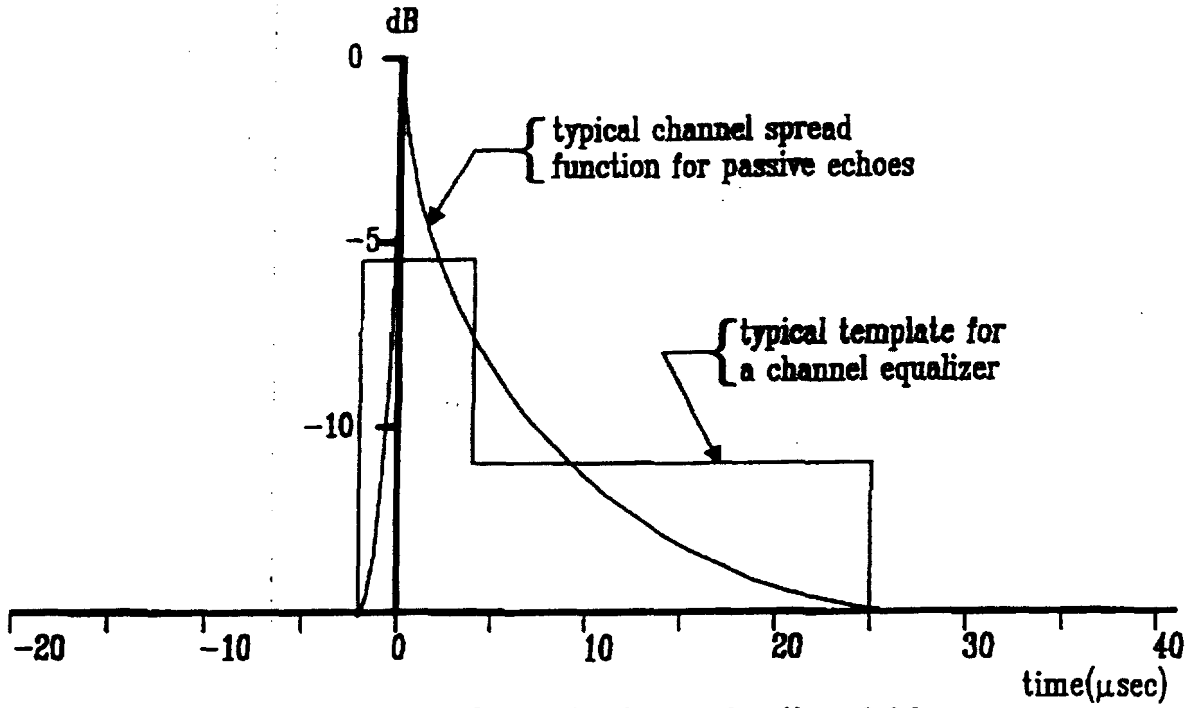


Fig 1: Relative echo amplitude as a function of delay and template for passive echoes

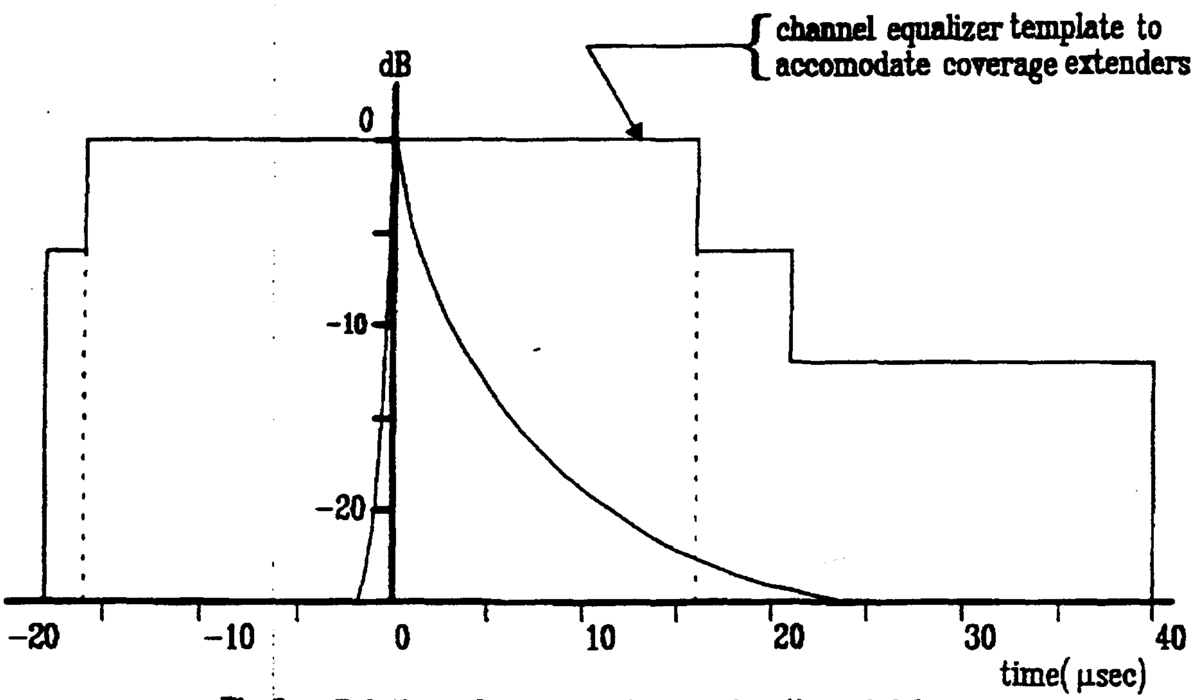
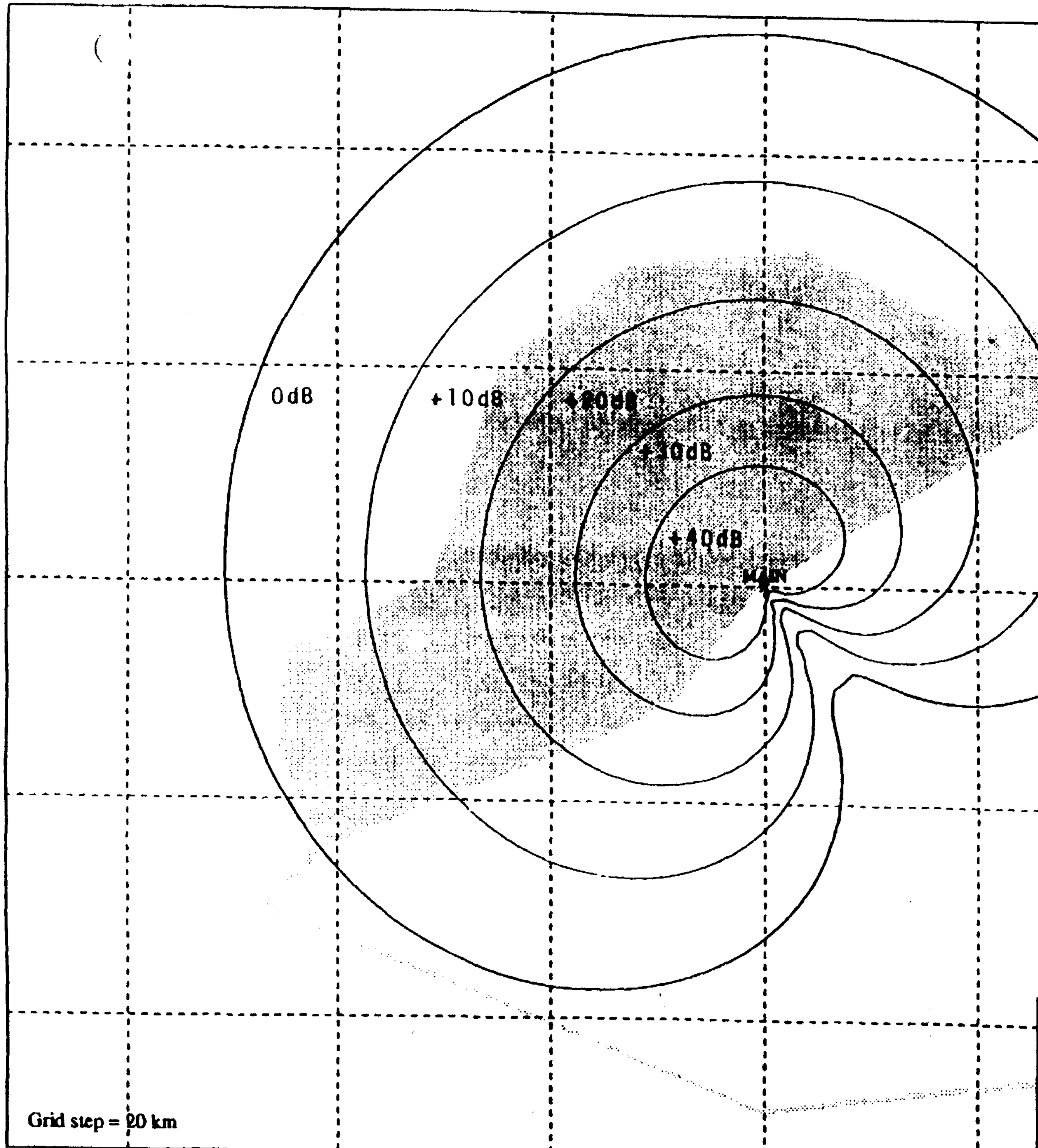


Fig 2: Relative echo amplitude as a function of delay and template for active and passive echoes



CRCDAB contour map

Project name is c:/crcdab/projects/toront_e.cas
Generation quality:HIGHEST
Date (DDMMYY) = 09/06/1992 , Time = 14:27:24

Toronto 50Km coverage
Single transmitter

COFDM coverage synthesis Version 1.4

Date (DDMMYY) = 09/06/1992 , Time = 14:27

System parameters

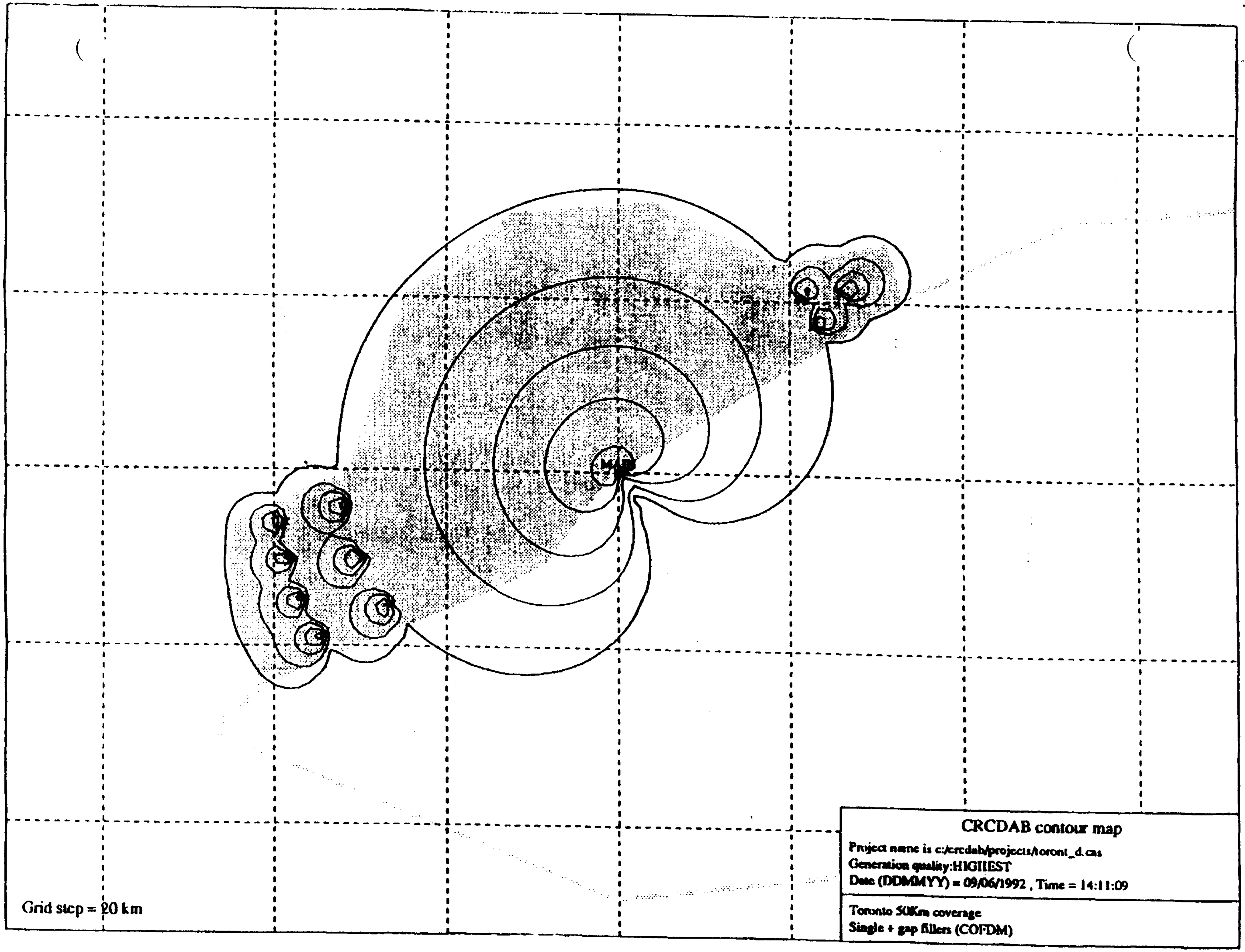
Curves show margin above system operation threshold (dB)
Horizontal span = 150 Km
Frequency = 645 Mhz
Symbol period = 32 usec.
Guard Interval = 100 %
Useful bit rate = 26430 kbit/sec.
Spectrum efficiency = 4.405 bit/Hz
Minimum Eb/No = 3.56 dB
System & hardware margin = 3 dB
Propagation model = CCIR 370 Corrected
Receiver antenna height = 10m
Location availability = 50 %
Time availability = 90 %

2. Receiver parameters

Antenna gain = 10 dBi
Antenna noise temperature = 160 K
Coupling and filter losses = 4.9 dB
Receiver noise figure = 10 dB
Receiver figure of merit = -29.461 dB/K
Synchronisation algorithm: Centre = linearly weighted mean echo

3. Transmitter parameters

Transmitter name	Position X	Position Y	ERP (W)	Pattern	Height (m)	Azimuth (degrees)	Delay (usec)	BackLobe (dB)	In us:
MAIN	0	0	1750	Broadside 1 dipole	300	-40	0	-40	YES


MAB
Grid step = 20 km
CRCDAB contour map
Project name is c:/crcdab/projects/toront_d.cas
Generation quality:HIGHEST
Date (DDMMYY) = 09/06/1992 , Time = 14:11:09
Toronto 50Km coverage
Single + gap fillers (COFDM)

COFDM coverage synthesis Version 1.4

Date (DDMMYY) = 09/06/1992 , Time = 14:11

System parameters

Curves show margin above system operation threshold (dB)
Horizontal span = 150 Km
Frequency = 645 Mhz
Symbol period = 160 usec.
Guard Interval = 20 %
Useful bit rate = 26430 kbit/sec.
Spectrum efficiency = 4.405 bit/Hz
Minimum Eb/No = 3.56 dB
System & hardware margin = 3 dB
Propagation model = CCIR 370 Corrected
Receiver antenna height = 10m
Location availability = 50 %
Time availability = 90 %

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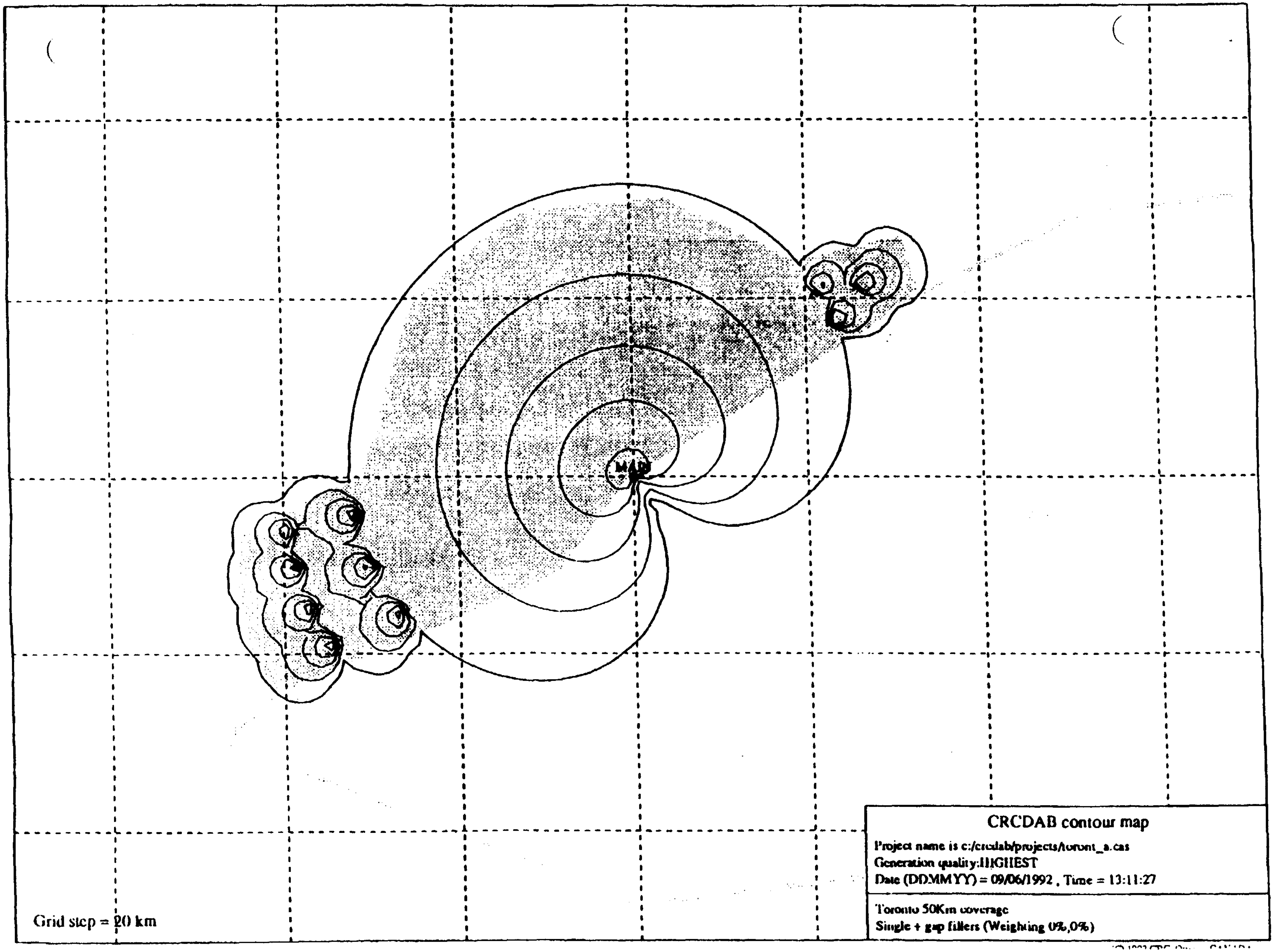
3. Transmitter parameters

Transmitter name	Position X	Y	ERP (W)	Pattern	Height (m)	Azimuth (degrees)	Delay (usec)	BackLobe (dB)	In us
MAIN	0	0	65	Broadside 1 dipole	300	-40	0	-40	YES
	21	20.676	5	Broadside 2 dipoles	30	45.445	0	-40	YES
	22.875	17.26	5	Broadside 2 dipoles	30	52.964	0	-40	YES
	-26.063	-15.103	20	Broadside 2 dipoles	30	-120.09	0	-45	YES
	-29.625	-9.8887	20	Broadside 2 dipoles	30	-108.46	0	-45	YES
	-38.625	-5.9332	5	Broadside 2 dipoles	30	-98.733	0	-40	YES
	-31.313	-4.1353	20	Broadside 2 dipoles	30	-97.523	0	-40	YES
	-36.375	-14.563	20	Broadside 2 dipoles	30	-111.82	0	-40	YES
	25.875	21.216	20	Broadside 2 dipoles	30	60	0	-40	YES
	-34.125	-18.699	25	Broadside 2 dipoles	30	-110	0	-40	YES
	-38.063	-9.8887	10	Broadside 2 dipoles	30	-110	0	-40	YES


CRCDAB contour map
Project name is c:/crcdab/projects/toront_a.cas
Generation quality:HIGHEST
Date (DDMMYY) = 09/06/1992 , Time = 13:11:27
Toronto 50Km coverage
Single + gap fillers (Weighting 0%,0%)
Grid step = 20 km

COFDM coverage synthesis Version 1.4

Date (DDMMYY) = 09/06/1992 , Time = 13:11:27

1. System parameters

Curves show margin above system operation threshold (dB)
Horizontal span = 150 Km
Frequency = 645 Mhz
Symbol period = 32 usec.
Guard Interval = 100 %
Useful bit rate = 26430 kbit/sec.
Spectrum efficiency = 4.405 bit/Hz
Minimum Eb/No = 3.56 dB
System & hardware margin = 3 dB
Propagation model = CCIR 370 Corrected
    Receiver antenna height = 10m
    Location availability = 50 %
    Time availability = 90 %

2. Receiver parameters

Antenna gain = 10 dBi
Antenna noise temperature = 160 K
Coupling and filter losses = 4.9 dB
Receiver noise figure = 10 dB
Receiver figure of merit = -29.461 dB/K
Synchronisation algorithm: Centre = linearly weighted mean echo

3. Transmitter parameters

Transmitter name	Position X	Y	ERP (W)	Pattern	Height (m)	Azimuth (degrees)	Delay (usec)	BackLobe (dB)	In use
MAIN	0	0	65	Broadside 1 dipole	300	-40	0	-40	YES
	21	20.676	5	Broadside 2 dipoles	30	45.445	0	-40	YES
	22.875	17.26	15	Broadside 2 dipoles	30	52.964	0	-40	YES
	-26.063	-15.103	40	Broadside 2 dipoles	30	-120.09	0	-45	YES
	-29.625	-9.8887	40	Broadside 2 dipoles	30	-108.46	0	-45	YES
	-38.625	-5.9332	10	Broadside 2 dipoles	30	-98.733	0	-40	YES
	-31.313	-4.1353	40	Broadside 2 dipoles	30	-97.523	0	-40	YES
	-36.375	-14.563	45	Broadside 2 dipoles	30	-111.82	0	-40	YES
	25.875	21.216	25	Broadside 2 dipoles	30	60	0	-40	YES
	-34.125	-18.699	45	Broadside 2 dipoles	30	-110	0	-40	YES
	-38.063	-9.8887	30	Broadside 2 dipoles	30	-110	0	-40	YES

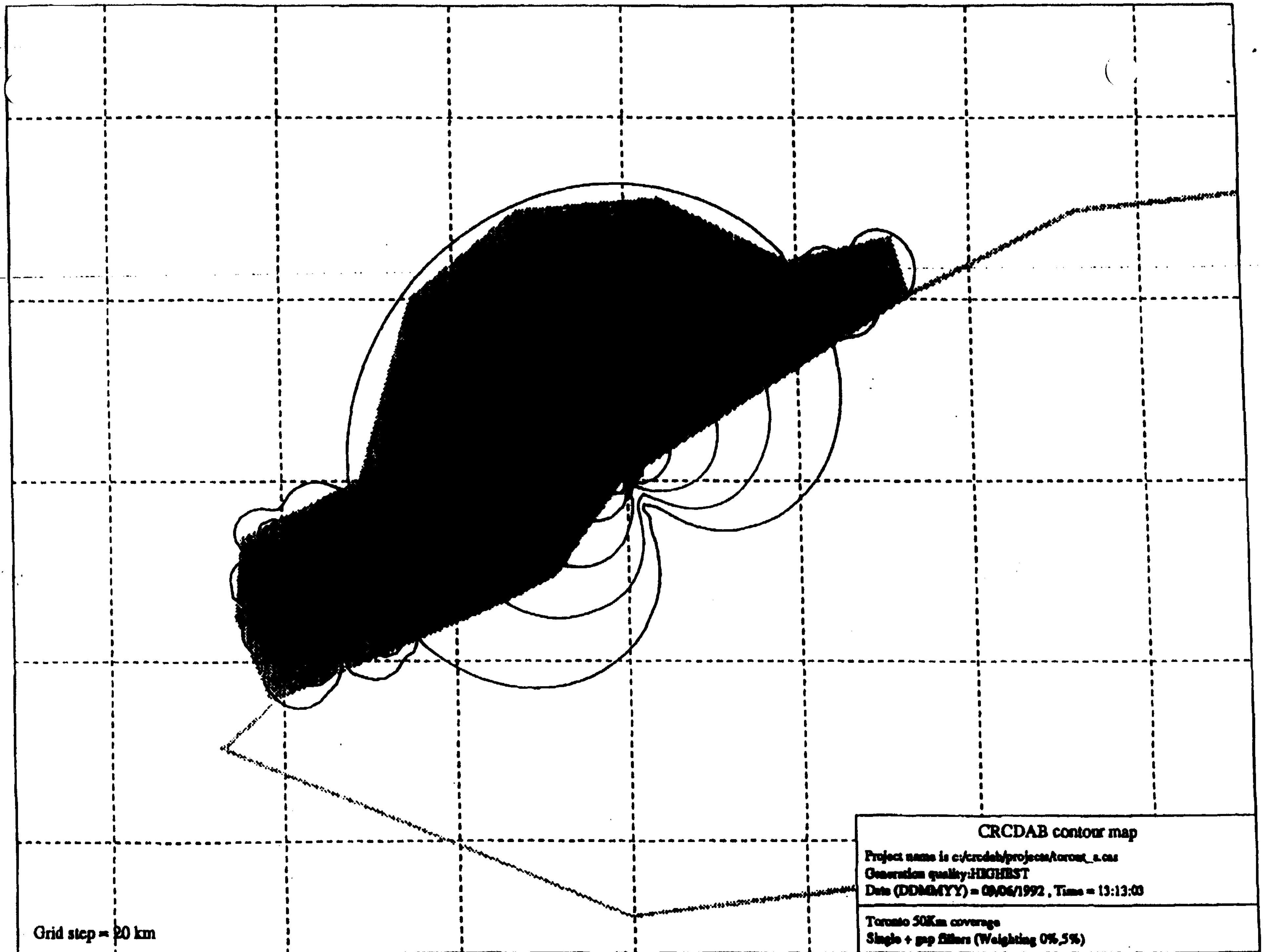

CRCDAB contour map
Project name is c:/crcdab/projects/torout_s.cas
Generation quality:HIGHEST
Date (DDMMYY) = 09/06/1992 , Time = 13:13:03
Toronto 50Km coverage
Single + gap fillers (Weighting 0%,5%)
Grid step = 20 km
(C) 1992 CRC, Ottawa, CANADA

FIGURE 6

IS/WP2-0225
21 JUL 92

FCC Advisory Committee on Advanced Television Service
Implementation Subcommittee Working Party 2 on Transition Scenarios

__Responses to Questions for Proponents__

Following are the questions posed originally to proponents with a summary of the answers from each arranged following the original question. Supplementary questions were posed to each proponent based upon an original set of responses. The answers to the follow-up questions are included in the summaries where the follow-up questions have so far elicited responses. In the interest of keeping this document from becoming any longer than necessary, the follow-up questions are not repeated herein. They are available upon request from IS/WP-2.

General

Q1. Is extensibility built into your system? If so, are there extensions to your system that require particular consideration during the initial (full, but not extended) implementation? What are the considerations that must be addressed as part of the initial implementation?

__NHK__

1. Future improvement of dynamic resolution by adding motion vectors (__all__ MUSE family members use only one currently).
   - Give up (reserve) data space — 60 kb/s for 140 vectors/field.
   - New receiver with additional 6 line memories and control circuits; original receivers can ignore new information.
2. Alternate media can use full MUSE quality if desired.
   - N-MUSE and MUSE use same algorithm, share same chip set.
   - Full-band MUSE digital input port can be provided in N-MUSE receiver to accept MUSE from some other service.

__GI__

1. Flexibility in compression/decompression supports various data rates from NTSC to HDTV and higher. Protocol and data structure are also flexible and can accommodate date from other services. Believe in concept of improved performance over time.

2. No answer yet to Specifics. Information on data/signalling, etc., soon to be released. No indication of how an initial DigiCipher receiver should be prepared to anticipate any particular extension(s).

   Present data structure is proprietary, not viewed as a "standard." Will be further defining protocol and willing to work with appropriate industry group to do so. Could incorporate aspects of SMPTE proposals.

Zenith/ATT

1. Possible extensions of performance of video and audio television services are discussed, variously implementable at the transmitter or the receiver, without impacting or making special provision in early receivers.

2. Data structure is particular to DSC-HDTV, not designed as a general communication system, but no particular ancillary data partitioning has been proposed. If the initial implementation of DSC-HDTV defines ancillary data as flexible packets with headers, new ancillary data services can be introduced later.

3. Headers/descriptors of the sort currently under consideration by SMPTE can be incorporated into DSC-HDTV global data packets with slight modification to the global data format. This would have to become part of the standardized system.

ATRC

1. Extensibility achieved by assigning a service code byte to each transport cell. New services, data (properly coded) can be added to digital stream at any time, for use only by receivers that recognize the particular code. Provides flexibility in mix of video, audio, and data for HDTV and in mix of services. There is no backward compatibility problem – early receivers ignore new services.

2. Have not identified any existing standard covering assignment of service types (ST). Those currently used arbitrarily selected, with additional types reserved for future use. Changing service type indicators is trivial.

3. Anticipate working with industry to finalize number and assignment of service types. If any standard is identified, will strongly consider its use.

MIT

1. Extensibility is provided by source-adaptive processing and the concept of headers.

2. Each image frame has a header containing information required or useful for interpretting the frame. Receiver can interpret header, properly decode, and ignore irrelevant information.

3. Current header protocols and data structures are proprietary, but flexible data structure permits adaptation to a reasonable industry standard.

4. Source adaptation sends source images in their native formats with any required format conversion done at the display. This is more efficient method in utilizing available bits than traditional approach of converting to a single format prior to transmission.

5. It is possible to use headers to select different encoding/decoding processes based on source format. CC-DC uses single encoding/decoding method with only the effective coding rate changed for the specific source.

Q2. How long following an Advisory Committee recommendation of your system will the detailed technical information necessary for the setting of standards and for the design and manufacture of both professional and consumer products be available?

NHK

1. The SS/WP-1 submission is a satisfactory introductory explanation. Standards setting information will be available after Advisory Committee recommendation for field test, before NPRM. Design/manufacturing information available during field test period. Part of coding is already in public domain in Japan.

GI

1. 0-3 months, for both standards setting and for design and manufacture.

Zenith/ATT

1. Both Zenith and AT&T have been responsive to this need in past standardization activities and will be for HDTV.

2. Development of standards and providing technical information for designers are separate issues. It is believed the proponent information for either or both will probably require 3 months to compile. Standards development may take an additional 3 months of effort by industry experts aided by the proponent.

ATRC

1. Much info is now available through ACATS documents, including SS/WP-1 submission, and through ISO-MPEG documentation.

2. Upon Advisory Committee recommendation (of ATRC system) detailed information will be available as quickly as possible given the scope of the task. Anticipate Advisory Committee and proponent(s) will agree on a timetable.

3. Anticipated time required to prepare final documentation on the order of 6 months.

MIT

1. A maximum of 4 months will be needed to supply technical information sufficient to begin the writing of both FCC Rules and industry technical standards. The information supplied during this period will be sufficient to permit start of IC and product design by manufacturers unrelated to system development program.

2. Personnel resources for development of necessary documentation will come from MIT's Advanced Television & Signal Processing Group and GI's VideoCipher division.

Q3. What provisions have you made for communicating information sufficient for design and manufacture to manufacturers of consumer and professional equipment? Do you have a program planned for providing direct support to help get such organizations up and running with your system?

NHK

1. NHK Engineering Services can provide all at any time under reasonable terms and conditions. Applies to any or all of proprietary info licensing, design diagrams, manufacturing know-how, and prototype evaluation.

2. Any proprietary information and manufacturing know-how necessary to commercial equipment, e.g. schematic diagrams, values of tap coefficients of digital filters, various kinds of parameters, will be subjects of doscussion of terms and conditions. Prototype evaluation service is included in technology transfer program but also available separately.

3. Information necessary to standards writing will be provided to any standardization organization without any restriction.

GI

1. Some internal discussions have taken place. GI has relevant experience in licensing and technical support. Such a function will be established for HDTV.

2. During remainder of 1992, GI will be exchanging information with a limited number of manufacturers. By the end of the year, GI will have developed a package for industry support.

Zenith/ATT

1. Nothing in place but intends to be responsive at the appropriate time. Both companies are experienced in this and business interests are best served by rapid deployment of all hardware, hence by rapid information dissemination.

2. Plan will include, but not be limited to, detailed technical information and diagrams, seminars as appropriate. The establishement of a program for direct support is premature until there is an unambiguous system selection.

ATRC

1. ATRC member companies are leading manufacturers of consumer and professional equipment and all experienced in launching new standards. Have a record of effectivley supporting technology transfer.

2. It is premature to discuss details of a technology transfer plan prior to selection of a system for field testing.

MIT

1. Both MIT and GI have experience in licensing and technical support and are communicating with manufacturers.

2. A specific plan for technology transfer has not yet been developed. MIT is working with GI to develop such a plan. The plan will involve technology transfer to both IC and product manufacturers.

Q4. What arrangements have you made with integrated circuit vendors for supplying chips for your system? What availability of ICs do you anticipate for other manufacturers of both consumer and professional equipment?

NHK

1. No specific arrangements. MUSE chips already commercially available, second generation due this spring. Specifically, no plans or arrangements to develop the N-MUSE-specific chips required.

2. Decoder should be built using and augmenting full-MUSE IC's. There is no economic advantage to a complete kit of dedicated N-MUSE IC's. Use of MUSE IC kit for part of the N-MUSE decoder saves time and development money, offers extensibility.

3. Use of Full MUSE chips for N-MUSE has little cost penalty since the MUSE chips and N-MUSE chips are of almost the same size and complexity. There might be slight memory savings for N-MUSE chips *vs.* MUSE but this is negligible. Some additional chips are necessary to interface MUSE IC's to N-MUSE system, but they are uncomplicated and would cost relatively little.

GI

1. GI has in-house capability and experience in VLSI for NTSC DigiCipher. Partitioning and estimation have been done for HDTV. Negotiating with vendors for HDTV IC development. Development time will be 18-24 months to availability to equipment manufacturers. (Presumed starting point from Q5: selection of system for field test will trigger hardware implementation.) (Also stated components and hardware may be available by the end of 1994.)

2. May make available 1st cut IC's, which will not necessarily conform to the final standards, for use in preliminary development of equipment.

3. On follow-up, expects to initiate serious IC development by mid-year 1992, and thus expects to have first IC's available by mid-year 1994.

Zenith/ATT

1. AT&T Microelectronics intends to be an industry supplier.

2. AT&T Microelectronics will provide production chip sets to support DSC-HDTV system introduction. In AT&T/ME business interests to make complete receiver chipsets available on a timely basis to other consumer electronics manufacturers and provide appropriate IC's to professional equipment manufacturers.

3. No response to follow-up question on how long following FCC decision chips will be made available to other manufacturers. Restatement of "timely" availability.

ATRC

1. MPEG-based compression is an advantage; some manufacturers are familiar with concept. HDTV MPEG expected sooner and lower cost than a proprietary scheme. (This HDTV MPEG content is about 50% of the IC kit — but not in existence with respect to either complexity or speed required.) IC development forecast at 18-24 months, except MPEG part may be quicker.

2. Various competing sources are expected; ATRC members will produce "appropriate" IC's for the open market. No specific arrangements for sourcing discussed.

3. IC design efforts at many companies will be triggered by an Advisory Committee recommendation and will be paced by a final FCC decision and timetable for implementation.

MIT

1. GI has in-house VLSI design capability. MIT/GI negotiating with IC vendors; expect chips to be widely available.

2. IC's are expected to be available within 18 months from the trigger point.